

## REMARKS

Applicant respectfully requests reconsideration of the present application in view of the foregoing amendments and in view of the reasons which follow. After amending the claims as set forth above, claims 24-70 are now pending in this application.

### **I. New claims 24-70 are supported by the specification**

Support for the new claims may be found throughout the specification, figures and originally filed claims. For example, support for the actual phase transition temperature between 41.9 and 80.6 degrees Fahrenheit may be found in Table I of the specification, located between the Abstract and the Figures. In Table I, n-tetradecane has the actual phase transition temperature of 41.9 degrees Fahrenheit and soy bean has the actual phase transition temperature of 80.6 degrees Fahrenheit. Many other materials provided in Table I have the actual phase transition temperature between 41.9 and 80.6 degrees Fahrenheit, such as n-heptadecane, which has an actual phase transition temperature of 77.1 degrees Fahrenheit.

Examples 1 and 2, Figures 17 and 19 and previously pending claim 13, such as page 19, paragraph 3, page 20, paragraphs 1-3 (paragraph 3 describes that the thermal balance is maintained for at about 4 hours), page 24, paragraph 3 (thermal balance is maintained for nine hours) and page 25 paragraph 3 (thermal balance is maintained for at least one hour) of the specification, provide support for the limitations in the last paragraph of claims 24 and 50 and in the last two paragraphs of claim 59. Pages 6-8 and Figures 1-11 illustrate various garment designs and components recited in the dependent claims.

The thermal loading of the phase change material in claims 47-49, 55, 61-64 and 69-70 is calculated from the numbers provided in Examples 1 and 2

of the present specification. For example, taking the data from Example 2 on pages 23-24,  $T_e = 15F$ ,  $Q_{loss} = 20.8$  B/hr,  $Q_{equil} = 19.9$  B/hr,  $h_f = 105$  B/lbm,  $A_f = 0.67$  ft<sup>2</sup>, provides a  $(Q_{loss} - Q_{equil})/h_f = (20.8 - 19.9)/105 = 0.009$  lbm/hr = 0.9 BTU/hr. Dividing the BTU/hr value by the  $A_f$  value provides  $0.9/0.67 = 1.34$  BTU/ft<sup>2</sup> for a one hour design, where the square feet dimension refers to the surface area of the garment.

Likewise, for  $T_e = 5F$ ,  $Q_{loss} - Q_{equil} = 6.8$ ,  $h_f = 105$  B/lbm,  $A_f = 0.67$  ft<sup>2</sup>, provides a  $(Q_{loss} - Q_{equil})/h_f = 6.8/105 = 0.065$  lbm/hr = 6.87 BTU/hr. Dividing the BTU/hr value by the  $A_f$  value provides  $6.87/0.67 = 10.3$  BTU/ft<sup>2</sup> for a one hour design. For a 9 hour design, using .25 inches of wax provides 94.03 BTU/ft<sup>2</sup> ( $T_e = 5F$  and  $63$  BTU/ $0.67$  ft<sup>2</sup> = 94.03 BTU/ft<sup>2</sup>). From example 1,  $840$  BTU/ $18$  ft<sup>2</sup> = 46.67 BTU/ft<sup>2</sup>. No new matter was added.

## II. The previous rejections

In the Final Office Action dated October 10, 2002, claims 1-19 were rejected under § 112, ¶ 1. Claims 1-23 were rejected under §§ 102 and 103(a) as being unpatentable over Hearst (US Patent 3,536,058), Feldman (US Patent 2,515,298), Bryant (US Patent 4,756,958), Salyer (US Patent 5,106,520) as evidenced by Bruemmer (US Patent 5,176,672). Claims 1-23 have been cancelled mooted these rejections. Applicants submit that claims 24-70 are also patentable over these references for the following reasons.

### A. Hearst

Hearst teaches only one thermal storage material: lithium nitrate hydrate, which has an actual phase transition temperature of 86 °F. Hearst also teaches to add a freezing point depressant to lithium nitrate hydrate. However, the freezing point depressant only lowers the effective transition temperature of lithium nitrate hydrate, but does not lower the actual phase transition temperature.

In contrast, claims 24, 50, 59 and 61 recite that the actual phase transition temperature of the thermal storage material is 80.6 °F or lower. This excludes the thermal storage material of Hearst. Since Hearst teaches that other thermal storage materials are inferior to lithium nitrate hydrate, there is no motivation to substitute the lithium nitrate hydrate of Hearst with another material having a lower actual phase transition temperature.

In fact, Example 1 of the present application teaches the use of a phase transition temperature of 71 F for a wet suit, by way of example. This temperature is below the actual transition temperature of 86 F taught by Hearst. Additionally, page 20, paragraph 4 of the present application teaches choosing phase transition temperatures that may be easily regenerated on a warm beach, for example, hence the choice of 71 F in this design. Example 2 of the present application teaches the use of a phase transition temperature of 50 F, even lower. As described on page 20, paragraph 4, this temperature is intelligently chosen to permit regeneration in a room temperature environment (such as a ski lodge). Page 15, paragraph 2 also describes the choice of the actual phase transition temperature of buffering phase transition temperature to be below room temperature, such that it can be regenerated naturally (i.e., at room temperature). Claims 46, 54, 62, 64 and 70 recite this feature. Hearst does not teach or suggest this limitation.

Furthermore, the lithium nitrate hydrate of Hearst is an inorganic material. In contrast, claims 45, 58 and 60 recite that the thermal storage material is an organic material. Table I of the present application provides many examples of various organic thermal storage materials, such as non-paraffin organic materials, pure organic materials, fatty acids of natural oils and waxes, hydrocarbon paraffins, polymers, rubber, crystalline hydrocarbons and other types of organic materials.

Finally, claims 32 and 51 recite that a thermal control layer is located on a first side of said thermal storage material adapted to face a wearer and an insulative layer is located on a second side of said thermal storage material adapted to face the ambient environment. The insulative layer being of greater insulative value than said thermal control layer. Thus, the phase change material is placed in closer thermal contact with the user than the environment. The structural combination of a (1) low phase change material actual phase transition temperature and (2) greater thermal contact of the phase change material with the user than with the environment, permits an extended life of the garment. For example, this structure requires 8 pounds of wax (104 B/lbm) for four hours in a wet suit, or two pounds of wax per hour. This results in a distinctive advantage in contrast to the 4 to 8 pounds of lithium nitrate per hour required in the wet suit design of Hearst.

**B. Feldman**

Feldman teaches that the phase transition temperature of the thermal storage material should be as close as possible to 37 °C (col. 2, lines 1-2). Feldman also provides a maximum range of phase transition temperatures of 28 °C to 45 °C (col. 3, line 9). Thus, there is no motivation to provide a thermal storage material with a phase transition temperature below 28 °C (about 82°F) in the device of Feldman because Feldman teaches that the phase transition temperature must be as close to 37 °C as possible.

Claims 46, 54, 62, 64 and 70 recite that the phase change material transition temperature is room temperature, to allow regeneration at room temperature. Feldman does not teach or suggest this feature.

Furthermore, the thermal storage material of Feldman is an inorganic material (see col. 1, line 55 and col. 3, line 61 and col. 4, lines 3-20). In contrast, claims 45, 58 and 60 recite that the thermal storage material is an organic material.

**C. Bryant and Salyer**

Applicant notes that page 7 of the Final Office Action asserted that certain limitations of claim 1 were not given patentable weight because they were directed to an intended use of an article rather than to structural limitations. Based on this claim interpretation, claim 1 was rejected over Bryant and Salyer.

Applicant disagrees with this interpretation of claim 1 and with the rejections of claims 1-23 under §§ 112, 102 and 103. However, in order to expedite the prosecution of the present application, claims 1-23 have been cancelled and new independent claims 24, 50, 59, 61 and 69 are presented.

Claims 24, 50, 59 and 61 recite structural limitations which are not taught or suggested by Bryant and Salyer. Specifically, claims 24 and 59 recite that the thermal storage material has a thermal mass at least equal to a difference between a heat loss from the thermal storage material to the ambient environment below the actual phase transition temperature of the phase change material and a metabolic heat absorbed by the thermal storage material for at least one hour. This is a structural limitation which distinguishes Bryant and Salyer, because it describes the properties of the thermal mass of the claimed material, which are not taught or suggested by Bryant and Salyer.

Likewise, claim 50 recites that the thermal storage material has a thermal mass sufficient to decouple a heat transfer between the ambient environment and the thermal capacitor and a heat transfer of metabolic heat absorbed by the thermal capacitor and that the thermal mass and the phase transition temperature of the phase change material are sufficient to maintain the phase change material in a partially solid and partially liquid state for at least one hour. This is a structural limitation which distinguishes Bryant and Salyer, because it describes the properties of the thermal mass of the claimed material, which are not taught or suggested by Bryant and Salyer.

The phase change material of Bryant is placed into microcapsules and incorporated into a fiber in such a way so as to provide a low thermal mass and a low thermal loading of the phase change material. The phase change material of Salyer is placed into pouches in such a way as to provide a high thermal mass and a high thermal loading of the phase change material.

The thermal design of Bryant is limited to using a high transition temperature phase change material for cold environments and vice versa, which is summarized as follows. For example, the background of the invention section of Bryant states that a phase change material can be used as an absorber to protect an object from additional heat and that the phase change material may also be preheated and used as a barrier to cold. Later, on page 4, line 20, Bryant describes the incorporation of micro-encapsulated phase change material into fibers. Bryant states the fabric may be used to make temperature adaptable clothing and other barriers, described as follows. Bryant describes gloves for cold weather use that are placed in a heated chamber prior to use. Bryant states that they are removed from the chamber and they will remain warm for an extended period of time. Alternatively, Bryant states that the gloves are cooled and a phase change material is solidified. When the gloves are exposed to a hot surface, the user will remain comfortable as he will perceive that they are remaining cool. Bryant also states that this concept can be applied to other applications including items of clothing such as shoes, environmental suits as well as other applications which require shielding of individuals or machinery from the hot and cold.

Bryant's description teaches one of ordinary skill in the art to use micro-encapsulated phase change material fibers to create (1) oven-heated gloves that, when warmed, can be worn to extend their period of use in a cold environment, or (2) to create chilled gloves that can withstand holding hot objects for long periods, and possibly (3) to create barriers to other extreme environments, which all are suggested by other prior art references.

However, Bryant does not teach or suggest the thermal capacitor or buffering thermal storage material having a cooling phase change material with a transition temperature below human body temperature, for protection in a cold environment, using metabolic regeneration. Nor does Bryant teach a design with phase change materials selected with transition temperatures below room temperature for use below room temperature and to accomplish regeneration in the room temperature environment, as recited in dependent claims of the present application. One of ordinary skill in the art would not be motivated to use the low transition temperature phase change materials of Bryant (or Salyer for that matter) in garments used in a cold environment without impermissible hindsight gleaned from the present application.

In contrast, the present specification and claims recite a way to design a garment containing a thermal storage material with a sufficient thermal mass and thermal loading to achieve the dynamic thermal capacitor feature (i.e., a buffering thermal storage material). The claimed structural garment design provides (1) a phase change material with a transition temperature below the human body temperature, in combination with a (2) mass sufficient to partially decouple the user from the environment, and optionally (3) to provide closer thermal contact with the body than the environment. This allows one to minimize the mass of phase change material required for the garment, while maximizing the duration of its effectiveness. Additionally, when designed for use in a cold environment, the claimed structure can be optimized further by choosing transition temperatures below room temperature to achieve regeneration in a room temperature environment.

### **III. Conclusion**

Applicant believes that the present application is now in condition for allowance. Favorable reconsideration of the application as amended is respectfully requested. The Examiner is invited to contact the undersigned by

telephone if it is felt that a telephone interview would advance the prosecution of the present application.

Respectfully submitted,

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**MARKED UP VERSION SHOWING CHANGES MADE**

In the specification:

Paragraph starting on Page 10, line 16:

Mathematically, the heat flux,  $Q$ , is proportional to the temperature difference,  $DT = T_{\text{skin}} - T_{\text{transition}}$ , divided by the thermal resistance,  $R$ , which is determined by the thermal path length:

$$[Q_i \propto DT = T_{\text{skin}} - T_i] \quad Q_i \propto \Delta T / R = (T_{\text{skin}} - T_i) / R_i$$

$$[R = R_1]$$

where  $T_1 > T_2 > T_3$  and  $R_1 < R_2 < R_3$

Paragraph starting on Page 18, line 3:

The disadvantage of the current practice to strictly use insulation for thermal control is that the thermal resistance is fixed in the diving suit. As explained above, to avoid overheating or chilling, i.e. thermal discomfort, a balance must be achieved between the heat desired to be removed from the body to maintain comfort,  $Q_{\text{equil}}$  and the actual heat flow out of the suit,  $Q_{\text{loss}}$ . Since environmental conditions change constantly and since thermal conditions of the [foot] body are directly linked to the changing environment through this fixed heat transfer path, no latitude exists to achieve this balance at conditions other than those at the single environment for which a solution exists.

Paragraph starting on Page 20, line 13:

For  $T_{e2} = 43 \text{ F}$ ,  $Q_{\text{loss}} = 619 \text{ B/hr}$  and for  $T_{e1} 33 \text{ F}$ ,  $Q_{\text{loss}} = 840 \text{ B/hr}$ . Regardless of the change in external environment and  $Q_{\text{loss}}$ ,  $Q_{\text{equil}}$  will be maintained as long as sufficient thermal capacitance of the phase change material is provided. Finally, the quantity of phase change material required to maintain this de coupling with the environment, assuming  $T_{e2} 33\text{F}$  and a 21 5

B/hr delta between  $Q_{\text{equil}}$  and  $Q_{\text{loss}}$  is computed by equation [4] to be equivalent to 2 lbm/hr.

$$\left[ \text{mass} = \frac{(Q_{\text{loss}} - Q_{\text{equil}})^2 t}{\text{hr}} \right] \quad [4]$$

$$\text{mass} = \frac{(Q_{\text{loss}} - Q_{\text{equil}}) t}{\text{hr}} \quad [4]$$

Paragraph starting on Page 21, line 29:

From these givens, one can compute  $Q_{\text{loss}}$  according to equation [5], below, to be equal to 21.4 B/hr in a 15 F environment and 24.5 B/hr in a SF environment. If one assumes no distribution of heat via the bloodstream, local chilling of the foot results and one can conservatively estimate a drop in temperature equal to 2 F/hr for the first case and [2.5] 6.3 F/hr for the latter. Although this is less likely the case, had  $Q_{\text{equil}}$  exceeded  $Q_{\text{loss}}$ , a rise in foot temperature would occur with a tendency towards overheating.

Paragraph starting on Page 24, line 8:

For  $T_{e1} = 15 \text{ F}$ ,  $Q_{\text{loss}} = 20.8 \text{ B/hr}$  and for  $T_{e2} = 5 \text{ F}$ ,  $Q_{\text{loss}} = 26.7 \text{ B/hr}$ . Regardless of the change in external environment and  $Q_{\text{loss}}$ ,  $Q_{\text{equil}}$  will be maintained as long as sufficient thermal capacitance of the phase change material is provided. Finally, the quantity of phase change material required to maintain this de coupling with the environment, based on the extreme chosen, is computed by equation [8]. Assuming  $T_e = 5\text{F}$  and a 6.8 B/hr delta between  $Q_{\text{equil}}$  and  $Q_{\text{loss}}$ , this mass is computed to be less than 0.1 lbm per hour.

$$\left[ \text{mass} = \frac{(Q_{\text{loss}} - Q_{\text{equil}})^2 t}{\text{hr}} \right] \quad [8]$$

$$\text{mass} = \frac{(Q_{\text{loss}} - Q_{\text{equil}}) t}{h_r} \quad [8]$$

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Paragraph starting on Page 24, line 17:

Since the thermal capacity of this 1/4" layer is 63 B, continuous thermal equilibrium and comfort is maintained for up to nine hours (for comparison, this same change of environments for the traditional boot resulted in an increase in the temperature drop of the foot from 2 F/hr to [2.5] 6.3 F/hr). After this point, the wax must be warmed and regenerated to its liquid state to maintain this same thermal equilibrium. If not, the thermal performance will simply reduce to that of the traditional ski boots where  $Q_{\text{loss}}$  is defined as in equation [5] with the additional resistance of the phase change material layer.